V.

Some Apparatus for Cutaneous Stimulation.

A. By M. F. Washburn, A. M.

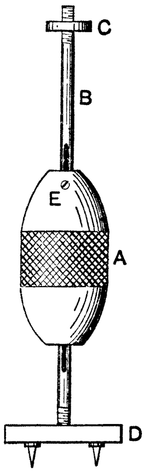

Fig. 1.

1. The first *Æsthesiometer* appears to be that described and figured by Czermak (*Physiol. Studien*, III. *Abth.*, 1855). Later instruments have followed the model of this, with the exception that both points are usually fixed at the same horizontal level, whereas in Czermak's *Stangenzirkel* "one limb (the terminal) is shorter than the other, and movable in the vertical direction." This latter arrangement allows of the application of two simultaneous pressures to a curved surface. But the general objection to the æsthesiometer—that there is no guarantee of constancy of stimulation-intensity from experiment to experiment—holds of all the slide-rule forms of the apparatus.

It appeared to us that the objection could be best met by a modification of the instrument, which would allow the two points to fall by their own weight, and with approximately constant friction, through a fixed support. And mechanical considerations narrowed this plan down to that of allowing a single rod, carrying the two points, to fall through such a support. The manner of constructing and affixing to the rod the cross-bar in which the points are inserted was suggested to us by the rough instrument employed by Professor Jastrow in his anthropometrical laboratory at the World's Fair.[1] The new æsthesiometer took final shape as follows.

Figure 1.

A is a heavy brass bulb, for holding in the hand. Through it passes a light steel rod, *B*, threaded at either extremity. The upper end carries any chosen one of a series of circular weights, *C*. The lower end is screwed into any chosen one of a series of blocks of hard rubber, *D*, which carry two rubber points, accurately distanced, and accurately turned to a final diameter of one-third mm. *B* is grooved over a certain portion of its length; and in the groove runs the point of a screw, *E*, the head of which is level with the surface of the brass bulb. The Cornell laboratory possesses a series of *D*, from a single point to a point-distance of 28 mm., the increments being 1 mm.; two *AB*; and weight-combinations from 15 to 90 gr. The dimensions of the whole apparatus can be chosen at pleasure.

The great advantages of this form of the æsthesiometer are: (1) The practical constancy of pressure, as between point and point, and as between experiment and experiment; if *B* is kept clean and well-oiled, its friction with *A* is minimal. (2) The absolute

[1] Professor Jastrow's perfected instrument is figured and described in the catalogue of the Garden City Model Works, 124 Clark street, Chicago, Ill., p. 1. The form with adjustable points has the disadvantage that the points themselves are formed each by a vertical and an inclined line, instead of by two lines equally inclined to the horizontal plane.

accuracy of the point-distances; there is no room for error of adjustment. Its disadvantages are: (1) Its restriction to the method of right and wrong cases; it can hardly be employed for minimal changes, unless two experimenters take part in the work done with it, and there are two *AB*, and a very long series of *D*—or unless *D* be remodeled, on the old slide-rule plan. (2) Its expense. (3) The fact that, at any other than a very moderate inclination of *AB* from the vertical direction, constancy of pressure is not obtained.

For demonstration experiments, *D* may be replaced, either by a rubber bar carrying roughly-pointed pyramids of hard rubber, as in Professor Jastrow's original apparatus; or (perhaps better) by a bar, *e. g.*, of wood, carrying a piece of sheet-rubber (one-hundredth inch) accurately cut to fine points at a definite distance from one another.

The instruments were made by the Pratt & Whitney Co., Hartford, Conn.

2. For *punctual* and *areal* cutaneous exploration, various instruments have been proposed, *e. g.*, by von Vintschgau (*Pflüger's Archiv*, X. 4. XVI. 318), Goldscheider (*du Bois-Reymond's Archiv*, 1887, 428), Dessoir (same *Archiv*, 1892, 308). After several failures, we have succeeded in constructing a fairly good, though by no means ideal, apparatus for the purpose. It is as follows.

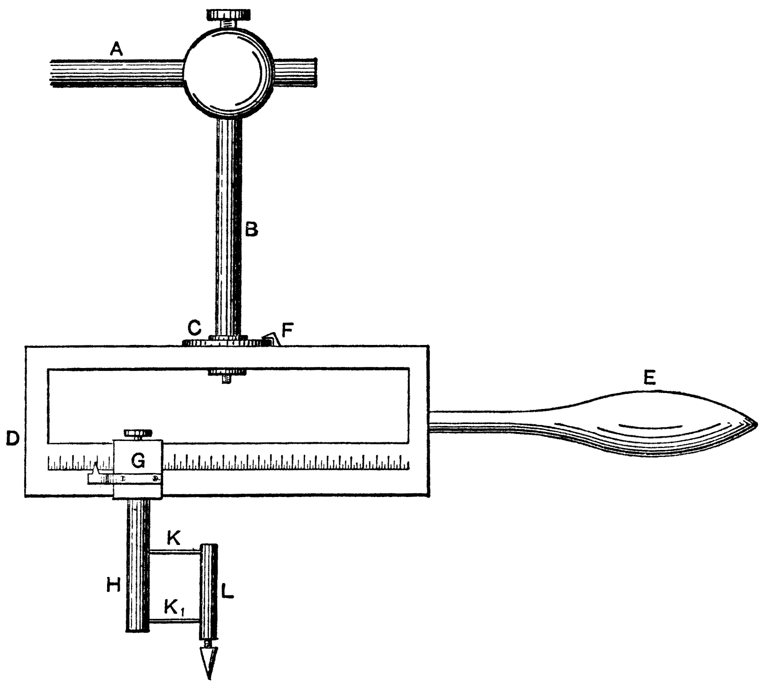

FIGURE 2.

A is a steel bar, movable in the vertical direction along the standard to which it is attached. *B* is a similar bar, movable around *A*. *C* is a fixed brass disc, divided up into degrees. *D* is a frame

of hard rubber, rotatable by the handle E around the extremity of B, and carrying a pointer F, which indicates the extent and direction of its movement, in terms of the scale marked upon C. The lower edge of D is provided with a mm. scale. Along this scale runs, in either direction, the brass carriage G whose pointer can be set at any number upon the scale. Attached to G is the brass rod H; and this latter carries on two stiff steel springs, K and K_1, the rubber point L. By means of L the skin can be explored, in circles of continually increasing diameter. The springs K and K_1 prevent any catching of L by inequalities of the cutaneous surface. "Pressure spots," *etc.*, can be accurately mapped by reference to the scale upon the disc C; and, if any one point of the stimulated area is known, a series of experiments can be repeated with complete accuracy of localization from day to day.

The introduction of K and K_1 is essential. An arm, revolving round the lower extremity of B, and carrying L directly, is unworkable; even if a spline-and-feather be inserted in B, the slight roughness of the superficial skin causes in this case a dragging of L, and prevents exact localization.

The point of L may be made detachable from its stem, to allow of the application of various forms (areal and punctual) of stimulus (for temperature, pressure, pain). A spring-point enables the instrument to be used as a sensibilometer.

This instrument was made partly by C. Krille, Leipzig, partly in the Yale and partly in the Cornell workshop. Its cost should not exceed $10.

For *linear* cutaneous stimulation, triangles may be cut from sheet-rubber (one-hundredth inch) and their apices inserted in light wooden handles. It is very easy to construct these simple instruments in sufficient numbers to admit of the employment of the method of minimal changes. Constancy of pressure must be learned by practice, as in the case of the ordinary æsthesiometer.

B. By E. W. Scripture (Yale University) and E. B. Titchener.

3. The *Kinesimeter* of Hall and Donaldson (*Mind*, X. 403) is a very imperfect instrument. The following criticisms suggest themselves:

(*a*) To start a machine by interlocking gears, means a variable error of $e = \pm \frac{t}{2g}$; where g is the number of teeth in the started gear, and t the rate of revolution of the motor gear; *e. g.*, if the motor gear make one revolution in two seconds, and move a gear with twenty-four teeth, the speed of the latter at the moment of starting dt will vary between $\pm$ one-twenty-fourth second. With a slow-moving car, it is sometimes possible actually to see the car move backward for an instant. As the speed increases, the error is diminished; but in the slow-moving kinesimeter it is very large. This objection is a fundamental mathematical one. In practice, no machines are started by interlocking gears where other methods can be employed.

(*b*) This variable error is thrown into the shade by the large constant error introduced, when the gears are not interlocked by a movement in the line connecting their two centers. Any movement around an axis simply pushes the second gear forward or backward. On a reproduction of the original instrument, this error amounted to about one-eighth inch in the movement of the car; the radius for the interlocking movement being about one and one-half inches. With the slow speeds used, the error would be rendered

negligible only by the employment of a radius of three feet or more.

(*c*) The stretching of the belt for the car was affected by placing the end-pulley on a spring. Every change of friction in the car would produce a change in the spring, a relaxation of the belt and a jerk in the movement of the car.

(*d*) To start a machine suddenly by connection with a kymograph throws more work on the latter, and lowers its speed, until the governor has time to react. During this time, therefore, the motion of the car is too slow.

(*e*) When the moving point meets with an elevation upon the cutaneous surface, it rotates upward; when it meets with a depression, downward. The upward movement differs but little from the horizontal; the downward movement is greatly accelerated. Between the fastest and slowest rates, for a nominally constant rate given by the car, there is a wide interval; the *m. v.* is very large.

[(*f*) In the presentation of the results of the investigation, nothing is said as to these errors and constants of the apparatus; no measurements of its accuracy are given; there is not even a statement of the *m. v.* of the final result.]

In constructing a kinesimeter for the Cornell laboratory, we have introduced the following improvements:

(*a*) This error has been eliminated by the employment of friction-gears. The difficulty caused by the increased pressure of the wheels against their axis is removed by allowing two friction-wheels to clasp a third.

(*b*) This error does not enter into friction gears.

(*c*) This error is eliminated by tightening the belt with a screw-fastening for the pulley, as in machines in general.

(*d*) This error can only be avoided by the employment of a heavy fly-wheel on a vertical axis, run by some form of small motor (water, electricity, kymograph, *etc.*).

(*e*) This error is partially eliminated by the direct up-and-down movement of an extra point added.

The new instrument in the Cornell laboratory was built in the Yale workshop. It can be supplied at the cost of \$90—\$100. Its salient features are as follows. (1) *Table.* Of brass casting, hard metal. Top planed perfectly true; V's planed at the same time as table. Legs fastened by four screws. One leg has adjusting screw, to compensate any unevenness of support. Nickel plated, with coating of copper first. (2) *Car.* Brass, nickel plated. Four wheels, turned on a perfectly true arbor. Bearings are bushings of hardened tool-steel; holes ground and lapped, so as to ensure perfect trueness in running. Side-looseness of car easily taken out, and wheels easily taken off their bearings. Shaft of hardened tool-steel, ground and lapped; perfectly true and round. Horizontal slide holding vertical rod readily adjustable by special mechanism. Vertical rod itself (carrying rubber stimulus-point, wheel, tube, or whatever is preferred) held in position by brass nut clamping conical head of support on horizontal slide. (3) *Rotating Power in Head.* Comprises three gears and three friction rolls. Held in two brass plates, nickel plated; bearings are hardened bushings, set firmly in place. Movement of car regulated by lever; two directions and rest. Pressure of driving rolls against principal roll maintained by two springs, the tension of which can be adjusted by two brass nuts on the end of a bar connected with lever. Since the rolls are held together by spring-pressure, and not by a positive stiff joint, any unevenness (dirt on surface, *etc.*) will not affect the movement. Rolls perfectly true, turned on centers. By moving top plate, the whole driving section can be

taken apart. Rubber pulley held on its bearing by small screw on top, with conically shaped head. Shaft counter-sunk to fit; tightening screw expands slotted end of shaft, and the pulley is so held firmly in position. Three notches in support holding reversing lever. Center notch keeps car at rest. Balanced pointer mounted on two hardened centers. Case in which gear is held entirely independent of outside case holding large friction roll. Pressure against driving roll will not interfere with shaft of rubber pulley, which is mounted on bushings of hardened steel; the friction obtained by pressing the rolls together has nothing to do with running of this shaft, the two pressures being independent. Endless cord propelling car is joined by a knot, fitting into a rest and slot affixed to the car. Adjustment for tightening cord is a pulley at the other end of the table, with thumb-screw beneath.

This kinesimeter has been thoroughly tested on the smoked paper of the kymograph. It was found to be absolutely accurate, to the degree of accuracy obtainable from the kymograph.